

**Introduction to the  
Hiram M. Chittenden Locks  
History and Issues**

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# Historic Events

- Since 1850's civic leaders and dreamers planned for a navigation channel from Lake Washington to Puget Sound.
- In the 1880's a small channel and lock at Montlake carries log to mills.
- Other navigation routes considered -- south Lake Union to Elliott Bay; Salmon Bay through Interurban; and from Lake Washington through Beacon Hill.
- In 1912 the Cedar River is diverted from Black River into Lake Washington completing the dissection of the Duwamish into 3 separate basins -- L. Washington/Cedar; Green R; and White R.
- 1916 Locks completed and Lake Washington lowered 9 ft to elevation of Lake Union. Fish Ladder was part of original project.
- By the 1930's at least two stocks have been extirpated - chum and pink salmon. Three new stocks introduced - Baker River sockeye, Green River coho and chinook.





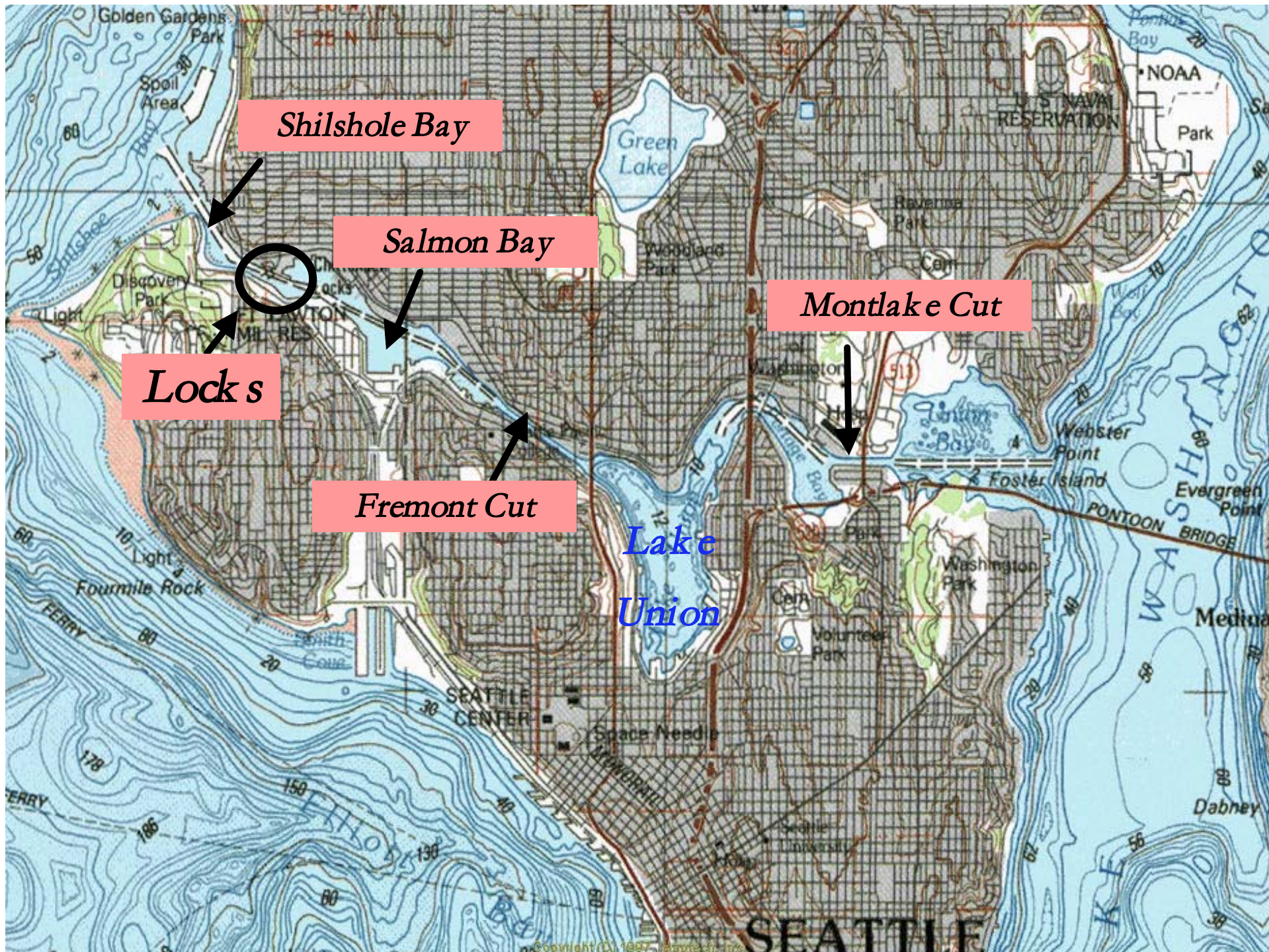
*Locks* →

*Lake  
Washington*

*Lake  
Sammamish*

*Historic  
Outlet at  
Black River* ↙







## **More Recent Historic Events**

- In 1958, during a drought, the lake reached its lowest elevation on record, 18.83 ft. The following year the most serious intrusion of saltwater into Lake Washington occurred.
- Mid-1960s sees the end of the METRO effluent discharge into south Lake Washington, reducing inflow by about 30 cfs.
- In 1966 a saltwater barrier is added to the large lock.
- In 1976 the fish ladder was rebuilt adding saltwater auxiliary water supply of 160 cfs. The ladder uses 60% of the total water budget during low flow conditions.
- In 1982 small lock disabled, experimentation with large lock for saltwater control -- begin period of miniflushing through 1994.
- Sea-lion predation of steelhead noted as increasing problem. 1996 change in Marine Mammal Protection Act results in removal of 3 nuisance animals and near cessation of predation at the Locks.
- In 1994 begin period of smolt passage experimentation and monitoring.



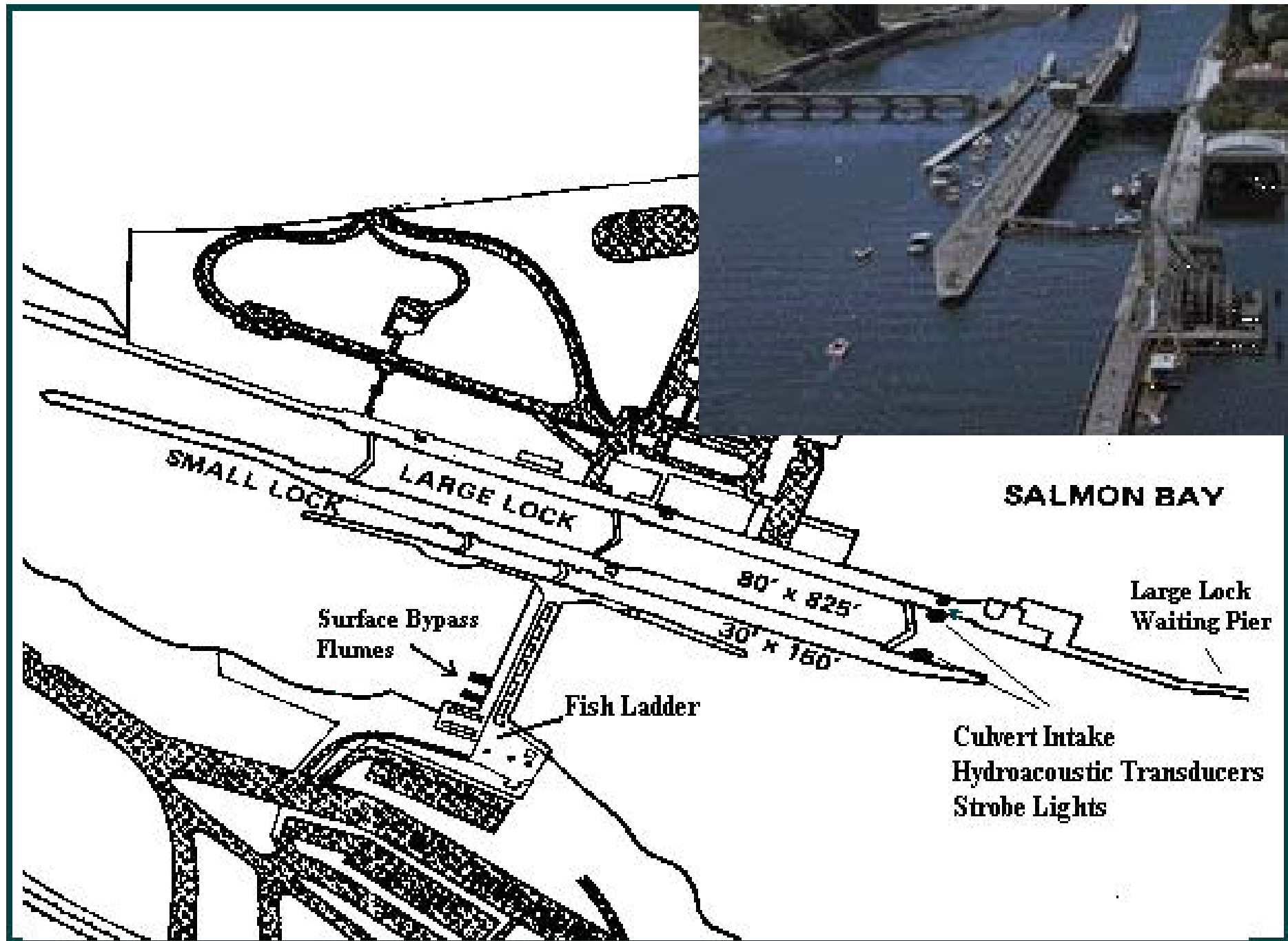
**Puget Sound**

**Flow**

**Ship Canal**

**Fish Ladder**

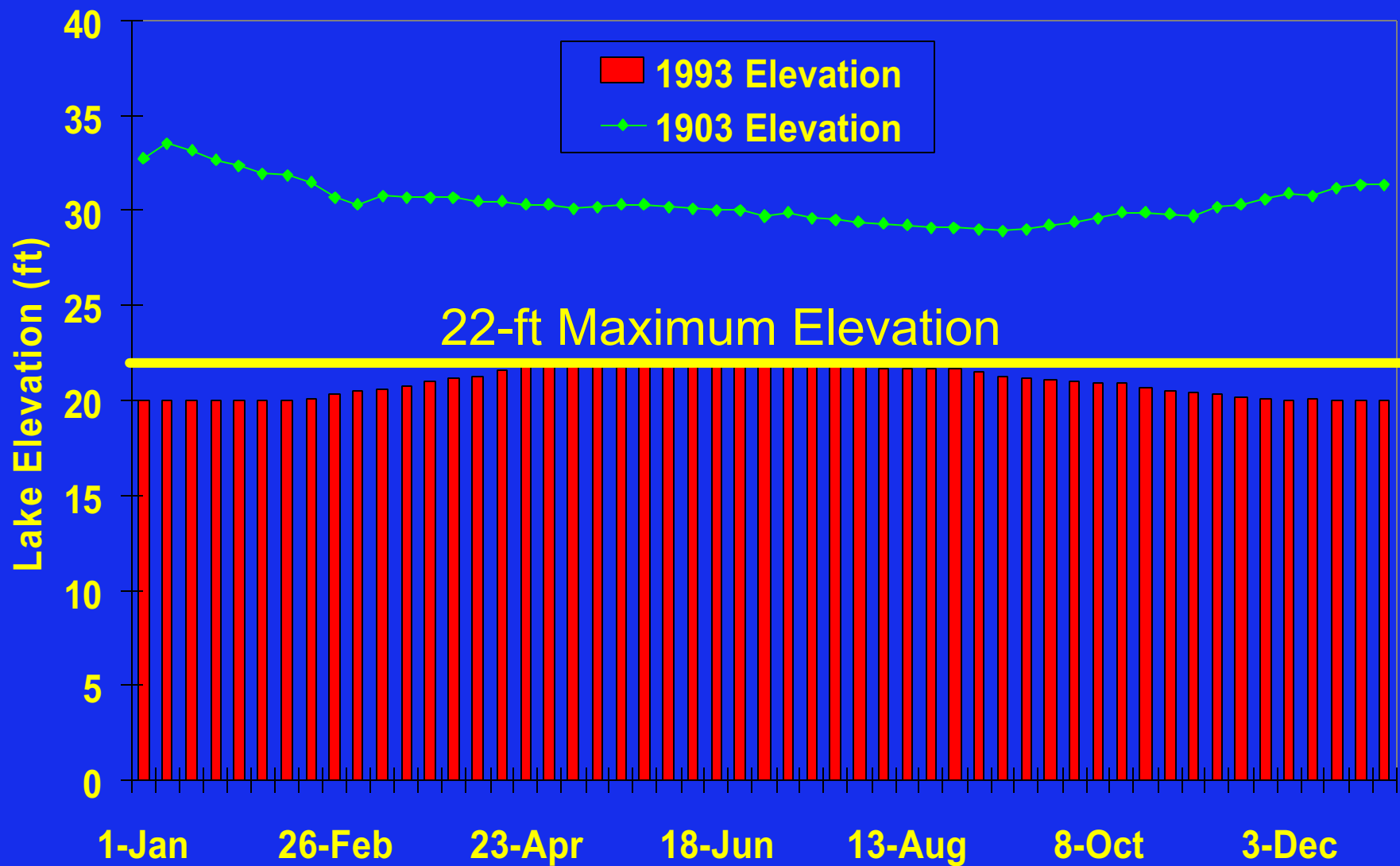




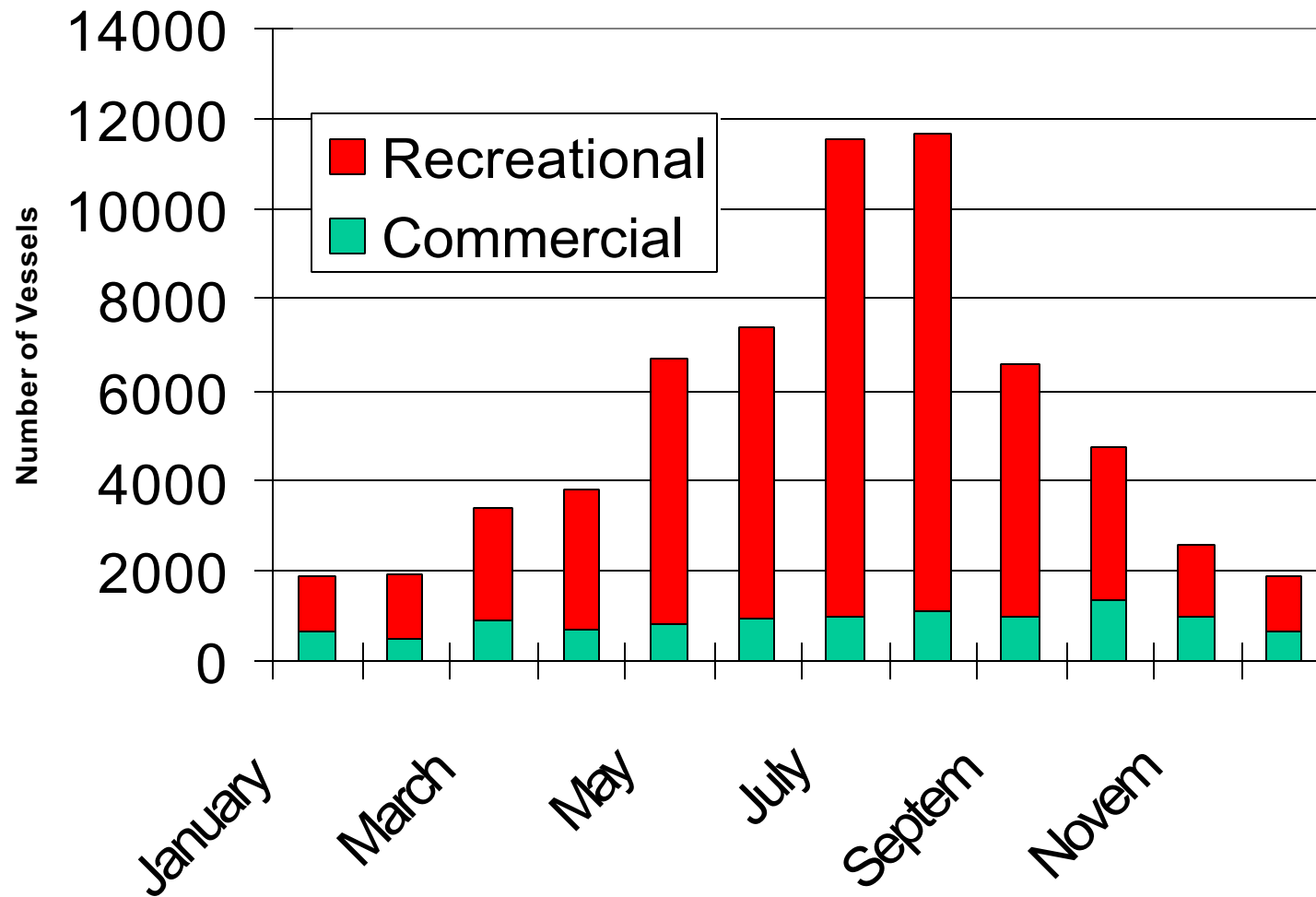
- Originally authorized in 1916 with a small lock, large lock, 6-bay spillway dam, fish ladder and 8.6 mile long ship canal.
- Authorized project purposes are navigation and fish passage.
- The locks passes more recreational craft than any other in the Western Hemisphere, peak usage from May-September.
- Secondary uses include flood and water quality protection (prevention of salinity intrusion into Lake Washington).
- The Locks and the Lake Washington Ship Canal is the outlet for a tri-lake system, Lakes Sammamish, Washington and Union: total watershed area is 1246 km<sup>2</sup>.
- The project was not built with adequate downstream fish passage facilities. Prior to 1997, most years from 50-90% of all smolts pass through the large lock and sustained heavy injuries.
- A smolt passage improvement project was completed in 2000 with the addition of 4 low-flow flumes, removal of barnacles, addition of strobe lights at large lock culvert intakes and modification of large lock filling procedures.



# Elevation of Lake Washington Pre (1903) and Post Ship Canal (1993)



# Vessel Traffic by Month



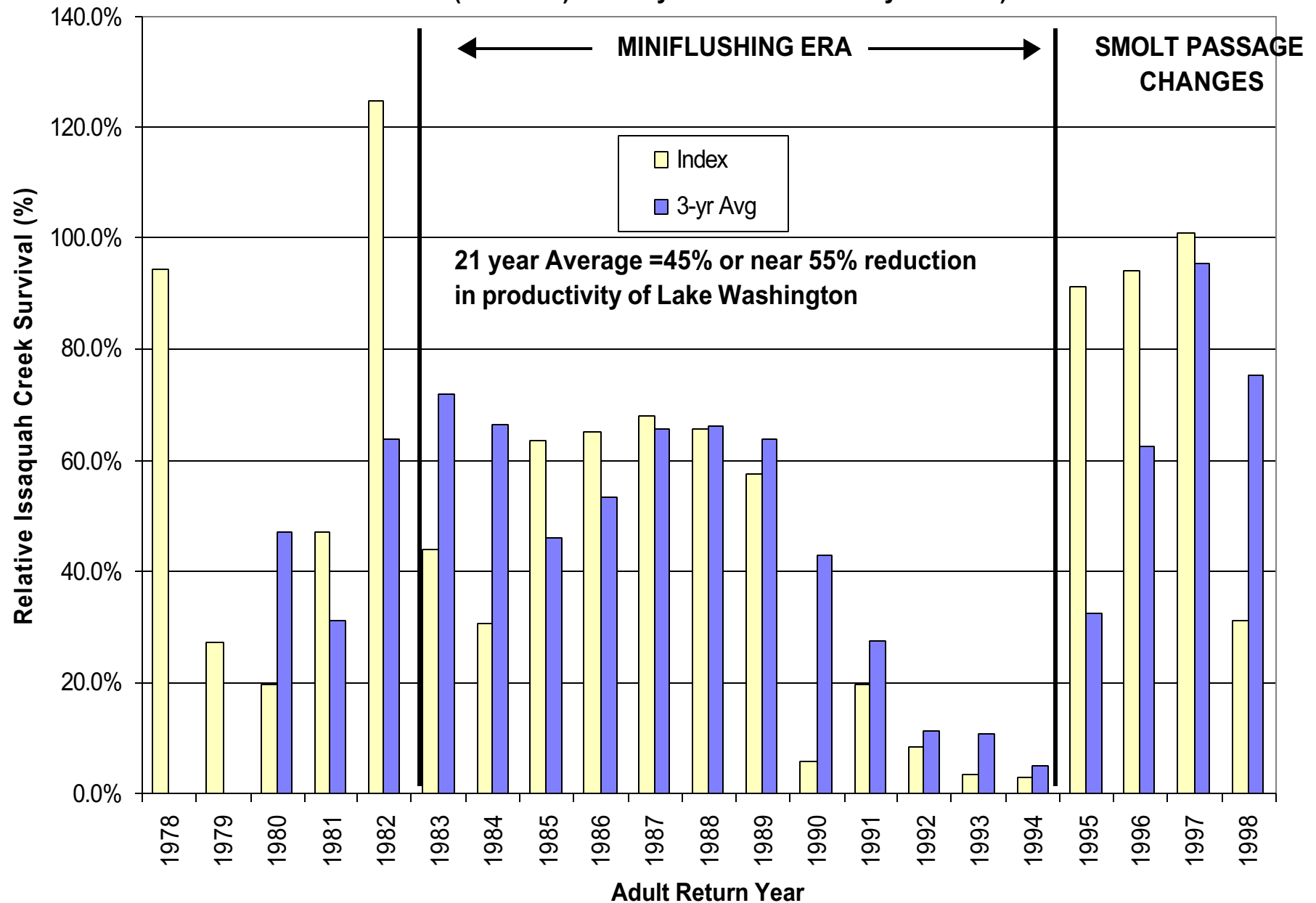


# Issues

## Juvenile Fish Passage

- *Mortality and injury of juvenile salmon passing through the Locks requires improved conditions.* Fish passage improvements were completed in 2000 with full implementation by 2001: through structural and operation changes including experimental technology.
- *Have fish passage changes actually improved fish passage survival.* Monitoring and evaluation in 1998, 2000, and 2001 (hang-around for the next couple of presentations).
- *There isn't enough water in most years to run smolt passage flumes.* Evaluating non-structural (saltwater management/lake elevation) and structural alternatives to find more water.
- *What is the best way to use the water.* Developing conceptual model on fish passage and functional use of the estuary. Monitor and evaluate migratory behavior throughout system -- L. Washington, Ship Canal and Shilshole Bay (P. DeVries/B. Footen).

## L. Washington Hatchery Coho Salmon Smolt-to-Adult Return





# History of Passage Experiments

- \* 1994 Slow Fill Experiment by Lockmasters
- \* 1995 Prototype Low flow Flume @ 80 cfs
- \* 1996 Begin Monitoring Entrainment in L. Lock
- \* 1997 Experiment with Low Frequency Sound
- \* 1997 Netpen Testing of Sound and Light
- \* 1998 Monitor Slowfill in L. Lock/Test Strobe Lights
- \* 2000 4 New Flumes@400 cfs; Slowfill as SOP;  
Removed Barnacles; installed Strobe Lights;  
Begin use of Passive integrated transponders
- \* 2001 Begin use of Strobe Lights

# Spillway : prototype flume 1995-1999 and four new flumes 2000

## Prototype



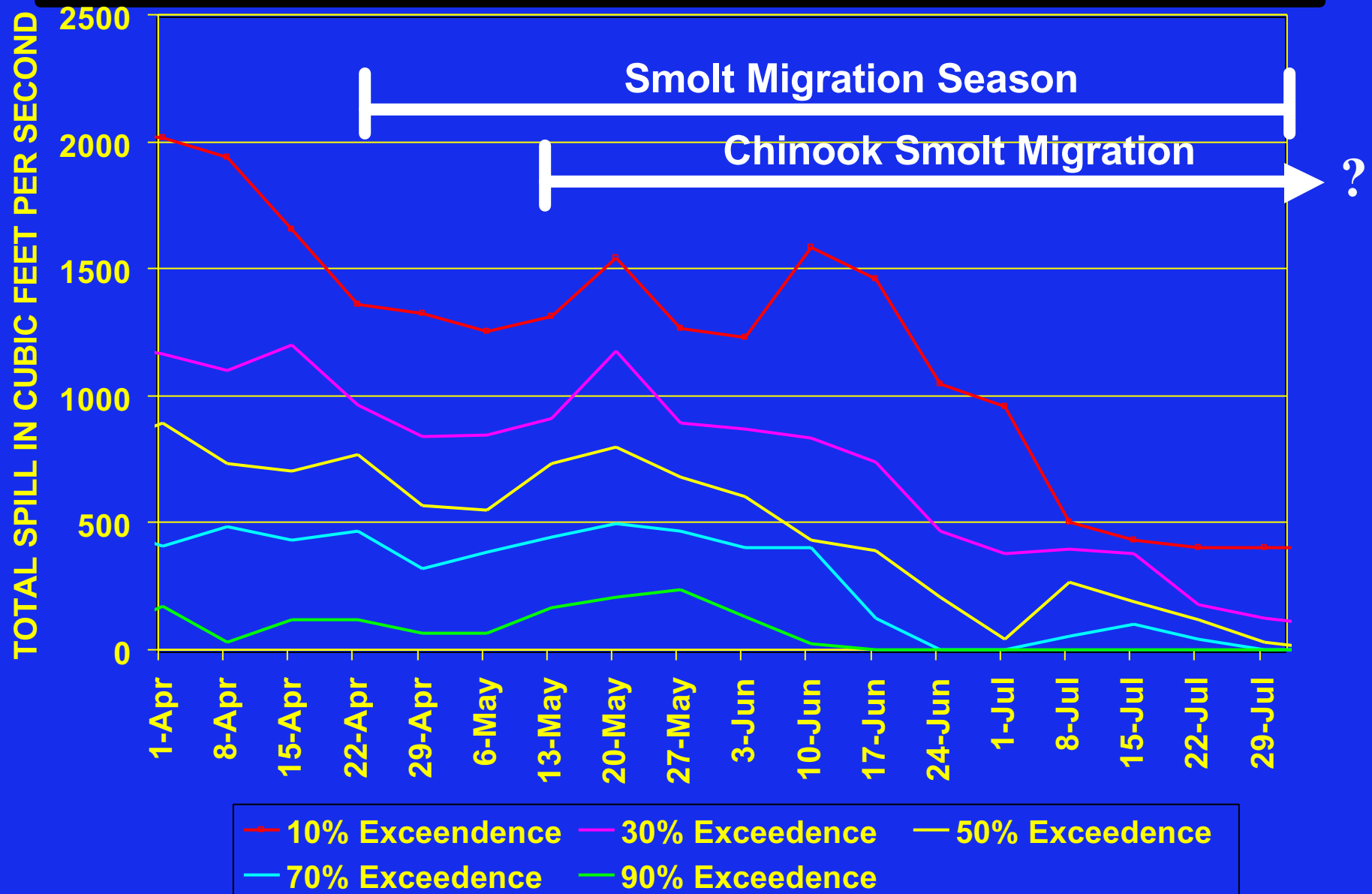
## 4 New Flumes



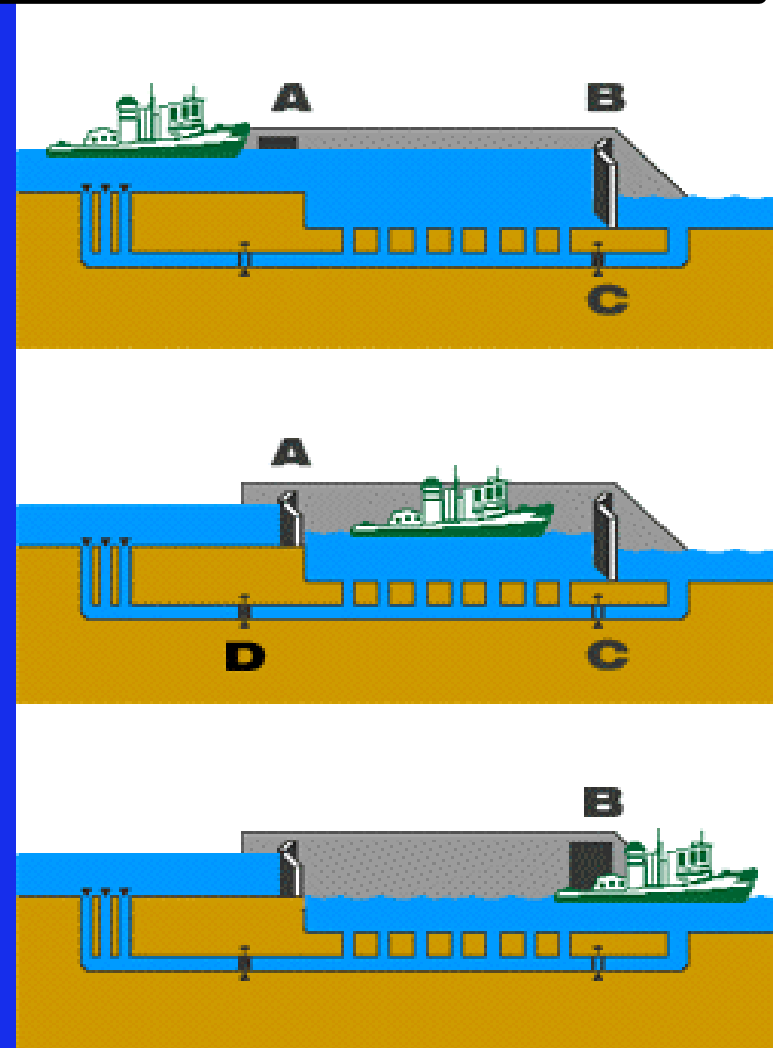


# How Much Water? When?

## Summary Hydrograph for Available Spill

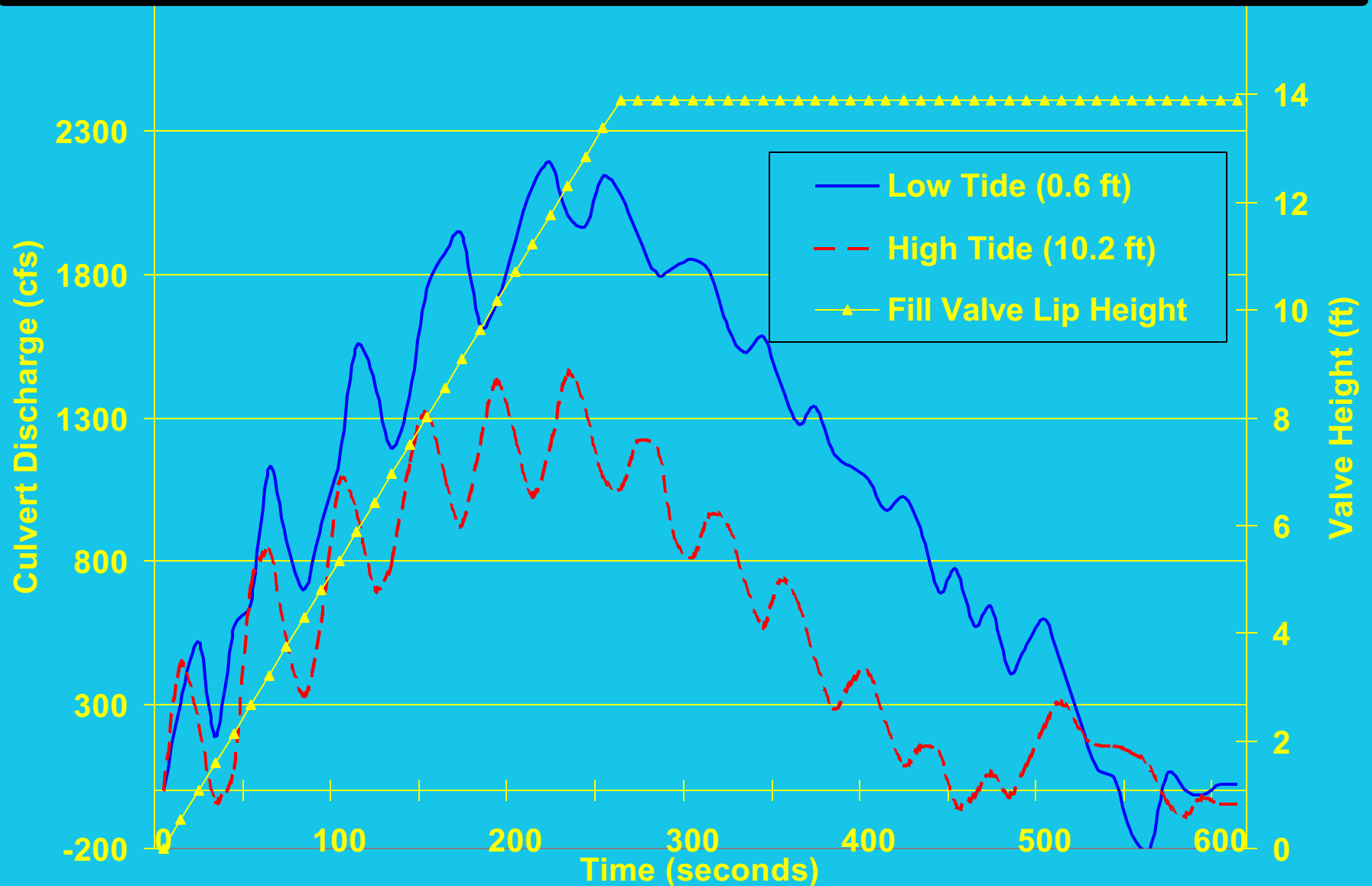


# Large Lock : Chamber and Intrusion of Saltwater -- It's Not Your Typical Tidal Action



Locking boats through the large and small locks results in an short-term exchange of freshwater and saltwater

# Large Lock : Culvert Discharge during Filling of the Locks is Equivalent to a 10-Minute Large River Freshet





## **Large Lock : Culvert Intake, Portal and Barnacles -- High Velocity, Bends and Barnacles**

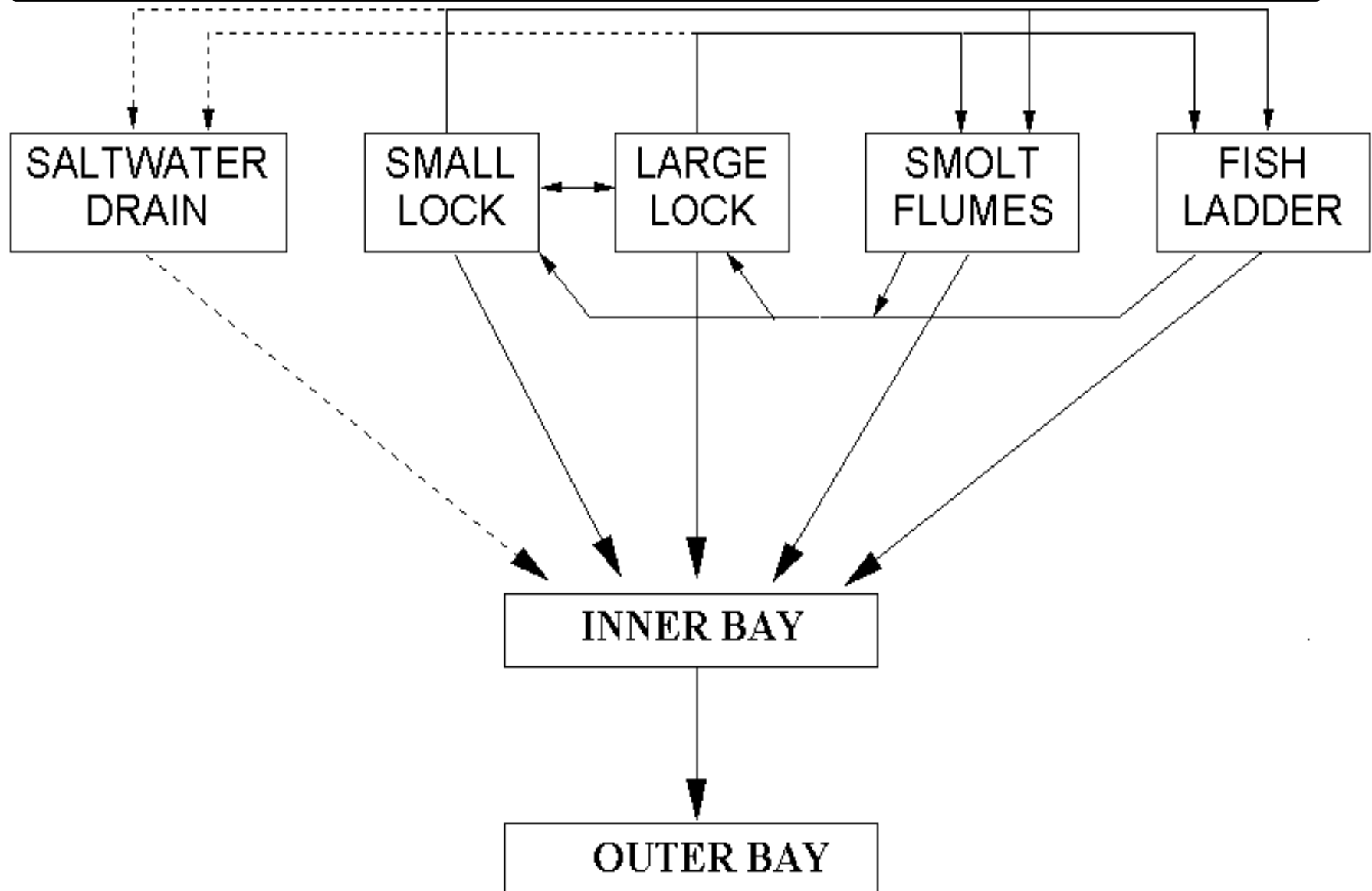


**Inside the filling culvert, with barnacles clearly visible on bottom and part way up sides.**

## Strobe-Lights -- Do Smolts Like Disco?



# Conceptual Model of Fish Passage Routes or *The Complexion of Our Connections*





# Issues

## Estuary and Adult Fish Passage

- *Can the functional value of the “neoestuary” be improved.* Monitoring information with hydrologic modeling could be used to shape water releases (river plume). Conceptual values include -- concentrating freshwater releases through flumes which concurrently improves fish passage opportunities, increases size of the freshwater lens, reduces salinity and temperature gradients, and exports food (Daphnia) and nutrients. Pilot-work monitoring in 1999, continued in 2001.

## Adult Issues

- *Do severe environmental gradients need to be reduced.* Chinook pass through a 10-11 C temperature increase and 28 ppt salinity decrease change over 240 ft. What can be done?
- *Can we improve holding conditions above the Locks.* Mid-summer migrants reside in a small, localized area above the Locks for up to 50 days. Monitoring and evaluation are being used to develop concept of “coolwater refuge” -- See posters (D. VanRijn/M. Timco).